Large Lake Ecosystem Modeling and Prediction

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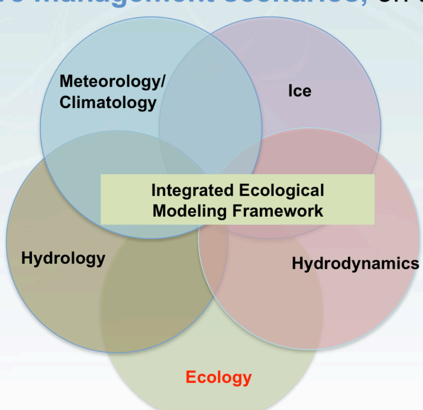
Ecology Team

Models **chemical and biological processes** to understand and predict the effects of **natural perturbations and human activities, including alternative management scenarios,** on the ecosystem



Key Scientific Questions

Can we forecast ecosystem services valued by stakeholders?

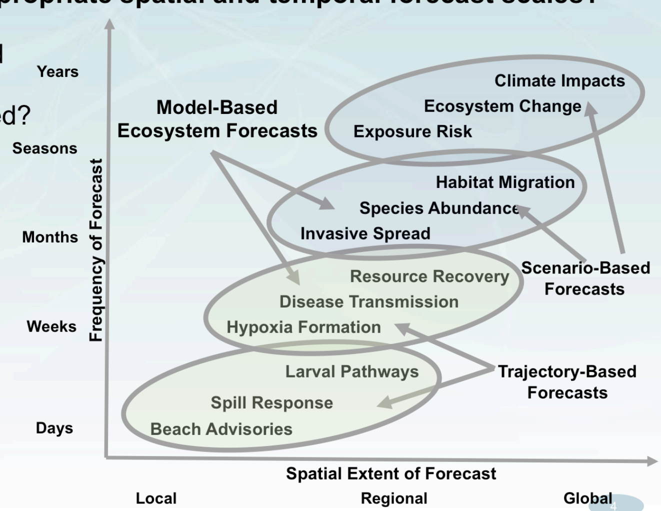
- Water quality (drinking, recreational, aesthetic)
- Healthy, sustainable fishery
- Resilience

There are many possible endpoints that would be useful to forecast (water levels, beach quality, responses to management).
Some of these endpoints are easier than others to forecast (in terms of resource requirements).
Differing stakeholders place differential values on these endpoints.
Limited resources require some knowledge of stakeholder values so that resources can be appropriately directed.

Key Scientific Questions

What are the appropriate spatial and temporal forecast scales?

- Scenario based
- Trajectory based?
- Real-time?



Most ecological forecasting is scenario-based. What will happen under differing conditions or alternative management actions?
There may be opportunities for real-time forecasting of a limited suite of endpoints as newer technologies emerge.

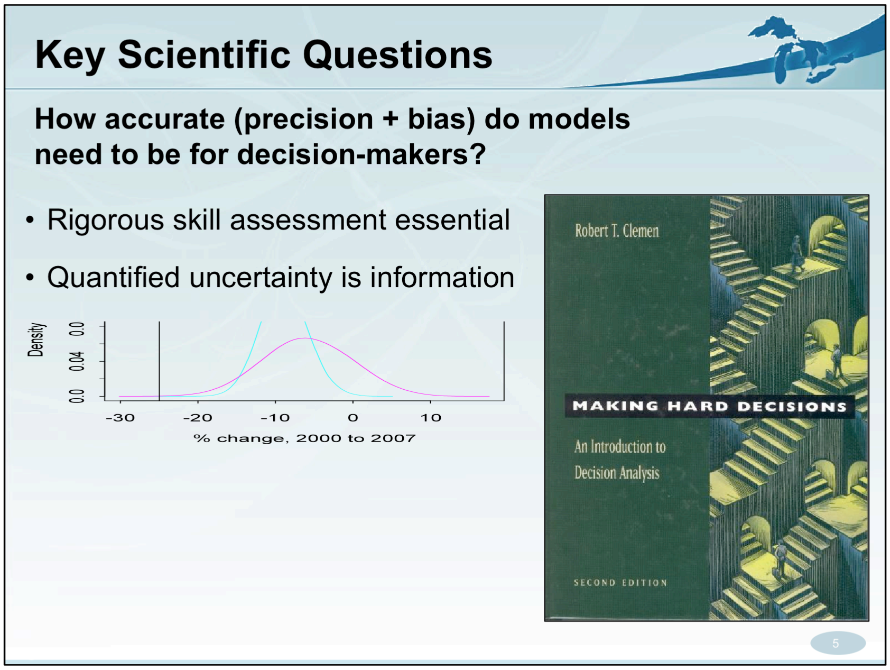
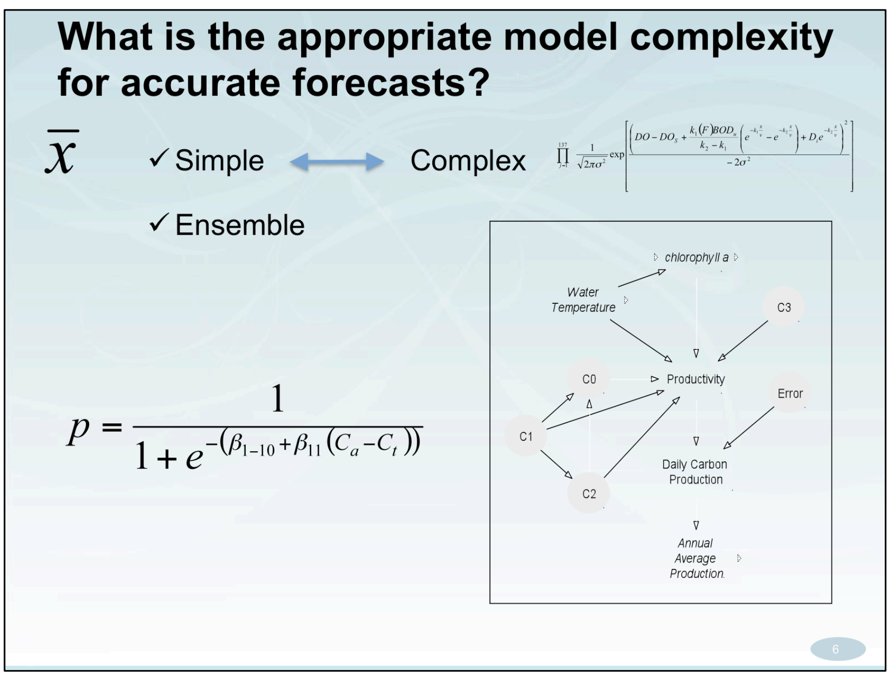


Figure:
BMA = Bayesian Model Averaging
DLM = Dynamic Linear Model

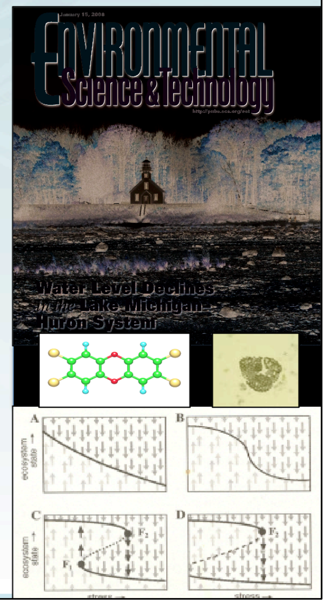
Decision science is a well-developed discipline – though decision theory is not widely known among environmental scientists. The book cover depicts one of many texts on the subject.



Models form a continuum from simple to complex.
Complex models require more information and make rigorous uncertainty quantification difficult.
There is no single "best" approach for all applications.
The use of multiple models of differing complexity with rigorous skill assessment and forecast averaging may be a useful approach.

What factors limit our ability to accurately predict ecological phenomena in the lakes?

- Data
- Process understanding
- Uncertainty propagation (physical + chemistry + biology)
- "Social-ecological systems are complex adaptive systems; understanding how their component parts function doesn't mean you can predict their overall behavior"



Different decisions require differing levels of model forecast accuracy. Identifying the biggest uncertainty sources helps to target resources to reduce uncertainties. Models are a good tool to identify uncertainty sources.

Quote from *"Resilience Thinking"* by Walker and Salt.

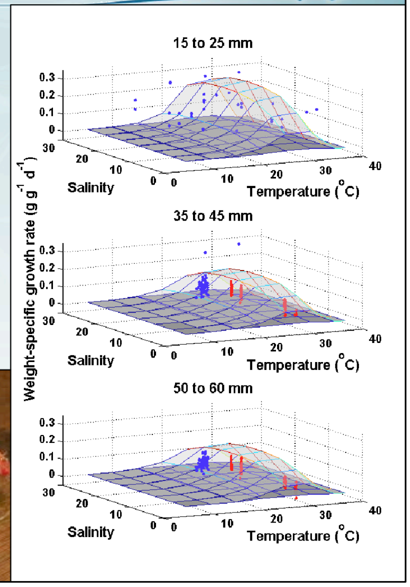
Products

- Biophysical model of Yellow Perch recruitment
- Muskegon River mega-model
- Food web models (Lake Erie, Lake Michigan, Northern Gulf of Mexico)
- Growth Rate Potential models (habitat quality models)
- Wind farm siting decision support model
- Gulf of Mexico Brown Shrimp model
- Saginaw Bay Bayesian Probability Network (Saginaw Bayes)

Gulf of Mexico Brown Shrimp Model

- Bayesian
- Bioenergetic
- Individual-based

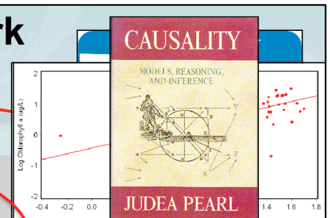
Used by Louisiana Office of Coastal Protection and Restoration and the Louisiana Coastal Authority Science Board to evaluate Mississippi River diversion effects on shrimp growth

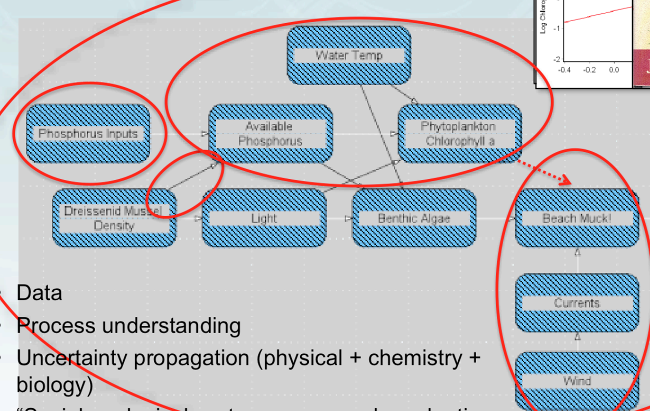


Some of our work extends beyond the Great Lakes to other coastal ecosystems.

We have a variety of tools – in this model we combined several of them.

Bayesian Probability Network (Saginaw Bayes)





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- Process understanding
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Uncertainty arises from many sources within a model.
Some model components will be better understood than others.
It is not well-understood if piecing together the component parts allows accurate forecasting – this question invites directed investigation.

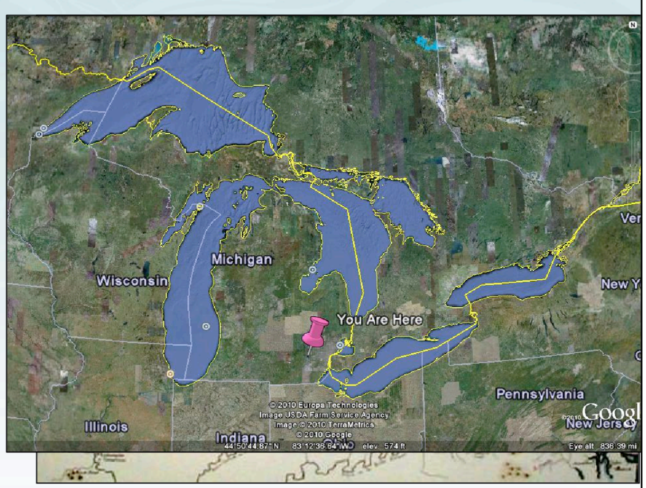
Partners and Stakeholders

- LA Office of Coastal Protection and Restoration
- LCA Science Board
- Louisiana State University
- University of Maryland
- Oregon State University
- University of Michigan
- MI Dept. of Natural Res. and Env.
- Lake Huron Technical Committee
- Lake Huron Binational Partnership
- Wayne State University
- Eastern Michigan University
- Michigan State University
- Duke University
- Nature Conservancy

Many partners and stakeholders.
Stakeholders and partners have become hard to differentiate in some projects.

Future Directions

- Continuity
- Adaptive Updating
- Coupling/ Integration
- Uncertainty Quantification, Propagation



As technologies and understanding evolve our sense of the Great Lakes and their behavior changes and our modeling approaches need to adapt.

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Questions?